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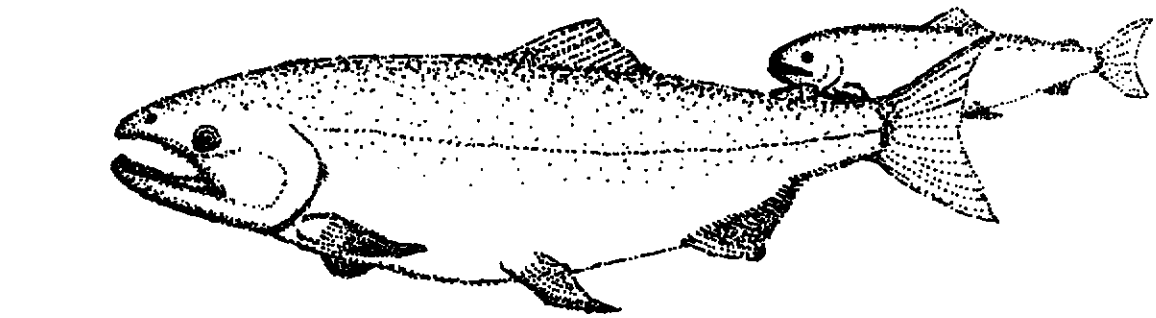
AN EVALUATION OF FALL CHINOOK SALMON PRODUCTION AT MAKAH NATIONAL FISH HATCHERY



WESTERN WASHINGTON FISHERY RESOURCE OFFICE

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An Evaluation of Fall Chinook Salmon Production at Makah National Fish Hatchery

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Abstract

The Makah National Fish Hatchery fall chinook program began in 1981 to increase chinook returns to the northern Olympic Peninsula and establish a tribal fishery in the Sooes River. This report presents results through 1991. Accompanying tag return data is complete for broodyears 1981 through 1986. Hatchery production has contributed primarily to sport and commercial fisheries in British Columbia, some in Alaska, and less in Washington. The run is successfully building but there has not yet been a directed fishery for chinook in the Sooes River. The primary goal of bringing the hatchery to full production has precluded establishment of a directed chinook fishery. Total survival to pre-terminal fisheries and the hatchery averages 1.10% to date.

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Introduction

Makah National Fish Hatchery (NFH) is located near Cape Flattery, Washington at the extreme northwestern tip of the Olympic Peninsula. It is situated 4.8 kilometers (3.0 miles) upstream from the mouth of the Sooes River. Since its authorization by Congress in 1973, the hatchery has raised fall chinook, coho, and chum salmon; and steelhead. Fish production began in October, 1981. The production goal for Makah fall chinook is four million, 6 gram fish released at the hatchery. As mitigation for an estimated three hundred adults displaced from the upper Sooes River by the hatchery weir, 120,000 advanced fry at 1.5 grams each are programmed for release in the Sooes River watershed above the hatchery. Eight hundred seventy females must return to the hatchery each year to meet the chinook production goal. If adults are passed upstream in lieu of the release of 120,000 advanced fry, one thousand and twenty adult females would be required to meet production. Assuming a 50:50 sex ratio, escapement needs are 2,340 fish.

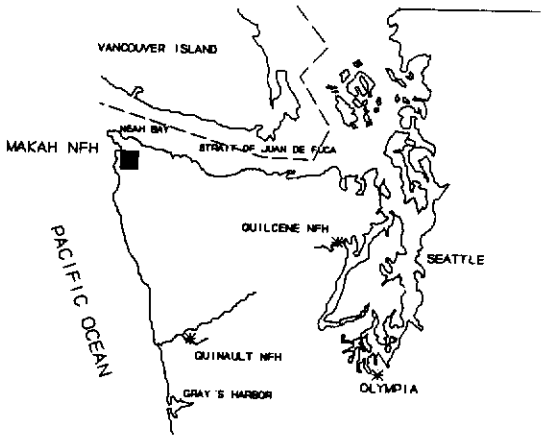

Figure 1. Western Washington locale map.

Data Sources

Most of the life history and hatchery production data used in this report came from the Fisheries Resources Evaluation Database maintained at the Western Washington Fisheries Resources Office (WWFRO), Olympia, Washington (US Fish and Wildlife Service 1991). The information is collected cooperatively by both the hatchery and WWFRO staffs.

Coded-wire tag recovery data came from the Pacific States Marine Fisheries Commission on-line database. Since Makah fall chinook recoveries are usually complete 6 years after spawning, only tagging information reported through the 1985 broodyear can be considered complete. Tagging information for the 1986 broodyear is also reported here, since the majority of recoveries have occurred by age 5. Tag recoveries reported by other agencies that were not expanded to represent unsampled fish were expanded for this report at a 20% sampling rate, the goal for coastwide sampling programs. Only 7 of the 561 reported tag recoveries from

Makah NFH tag groups required this arbitrary expansion. No adjustments were made for lost tags, lost heads, or sampled heads with no tag.

As originally constructed, the weir structure at Makah NFH was not completely effective at blocking fish from passing up the Sooes River. In recent years increased dike construction has improved weir efficiency and fish are now blocked on all but extreme tide and storm events. Data on adults returning to the hatchery before 1992 should be considered as minimum numbers, since uncounted adults are known to have passed upstream of the hatchery.

Release History

Fall chinook stock are known to have been released in the Sooes River at various times since 1958. The Washington Department of Fisheries released Soos Creek (Duwamish River), Deschutes River (WA), and Minter Creek stocks. In 1976 the US Fish and Wildlife Service released Quinault River stock and in 1977 released a Green River x Quinault River cross. Returns from these releases probably contributed to increased, but unsustained, fishery opportunities (Table 1). Since the hatchery began operations in 1981, only adults returning to the Sooes River have been used for chinook production.

Direct releases at Makah National Fish Hatchery since 1982 (broodyear 1981) total over 3.5 million fall chinook, representing 15 coded-wire tag groups (Table 2). Releases of advanced fry upriver from the hatchery as mitigation for natural fish displaced by the hatchery weir total 0.4 million fish, in 8 coded-wire tag groups (Table 3). Up to 260,000 fall chinook are regularly tagged as part of the Pacific Salmon Commission indicator stock program.

Hatchery Conditions

Standard Practices

Most adults enter the hatchery in October and November (Table 4). They are held until spawning in a receiving pond fed with Sooes River water. Spawning occurs within one week of entry to the hatchery (Table 5). Individual females are randomly paired with individual males to maximize genetic diversity. An individual male may be paired with more than one female in years when females outnumber males. Two-year-old jacks have been used in spawning since 1984 and represent about 6% of the spawned males.

Incubation occurs in the hatchery building in Heath incubator units fed with Sooes River water. Water temperature ranges from 1.7 - 15.0°C during incubation. When the water temperature is above 11°C the eggs are treated daily with a 15-min, 1667-ppm formalin drip to prevent fungus. At the eyed stage the eggs are shocked and picked with an electronic egg picker. They are then returned to Heath incubator trays. Hatch occurs in December. First feeding begins in February. The fish are fed BioDiet starter for one month, then converted to a diet of Oregon Moist Pellet. Up to 500,000 chinook can be held in the hatchery for first feeding. Any chinook beyond this number are ponded directly to the raceways and started on feed outside.

The fish are moved to outside raceways in February. Raceways are stocked with about 250,000 fish at 800 fish per pound. In early May, fish are taken from the raceways for coded-wire tagging. In the raceways, Sooes River is the only water source. Throughout their hatchery life the fish are on single-pass water flow.

Water flow has typically determined when Makah fall chinook are released. When flows in the Sooes River begin to drop in mid-May, the fish are released to the river by removing a plug and allowing the fish to exit the raceways through a fish release pipe. In 1991 and 1992 the fish were released in two groups, approximately half the production in each. The first group was released when fish loadings exceeded recommended safe levels for the available water flow. The second group was held longer in an attempt to increase fish size with the benefit of the added flow from the previously released chinook group. Each release group contained two tag groups and results will be evaluated as tag recoveries are made. This release protocol will be followed until tagging results indicate that a change is needed.

Coho and steelhead are released approximately four weeks before the chinook, which helps to avoid interspecific predation in the river.

Water supply

The only water source for the hatchery is the Sooes River, which is pumped into a 0.41 hectare (1 acre) settling basin which then feeds the hatchery by gravity flow. Available flow to the hatchery limits production at several times of the year and determines when certain hatchery activities are possible. As chinook, coho, and steelhead sizes increase in the late spring and early summer, available flow diminishes. This usually triggers the release of coho and steelhead sometime in April. Fall chinook are held until late May or early June, when flow

drops again. In the fall, adults cannot be held for spawning until there is adequate flow to maintain fish in the receiving ponds. Operation of the fish ladder cannot begin until fall rains provide adequate flow for holding adults in the hatchery. Ladder operation can be sporadic from year to year. High flows and high tides later in the fall and winter can combine to allow a portion of the returning adults to bypass the weir and ladder and move upstream uncounted.

Fish Health

The protozoan ectoparasite *Ichtyobodo (Costia)* is routinely found at Makah NFH and can be problematic in the spring when water temperatures increase and flows decline. Treatment consists of formalin baths at a concentration of 250 ppm for one hour. The fish are typically treated twice in the spring. The bacterial disease furunculosis is occasionally found in Makah NFH fall chinook. It is controlled with Terramycin®-treated feed.

In the fall of 1988, the causative agent of a form of viral hemorrhagic septicemia (VHS) was isolated from adult coho salmon at Makah NFH. At the time, VHS was thought to be restricted to Europe where it causes devastating losses in rainbow trout aquaculture. Fish disease policy dictated total elimination of all fish at facilities where VHS was isolated, thus the entire 1988 brood was destroyed and a complete station disinfection took place in early 1989. Replacement fish were brought in to allow coho and steelhead production, but no replacement for the 1988 chinook brood was available. In the research conducted after the Makah VHS isolation, many things were learned. The virus has since been found in single year-classes of adults returning to Orcas Island, Soleduck Hatchery, and Lummi Bay. Marine infections in Pacific cod have been documented from Alaskan waters. Most importantly, it has been found that the VHS strain isolated here in North America is different from that found in Europe, and it is now thought that the agent has always been present in the marine environment but had never been previously detected. The agent has not been detected at Makah since the first isolation and policy changes will probably allow for a less drastic approach to fish disease control if future detections are made.

Adults

Fall chinook - coho run timing

During the time that hatchery production has become established, it has become apparent that chinook and coho overlap in their entry timing to the Sooes River (Figure 2). When coho were

brought to the Sooes River to increase runs, both Quilcene NFH (early returning) and Quinault NFH (later returning) stocks were used. This overlap has reduced fishing opportunity for coho since the river is closed to protect chinook returning to the hatchery. Since 1987 the hatchery has selected later returning coho for propagation in an attempt to increase the separation in entry timing between chinook and coho. Results from the selection process have been variable (Table 4). Coho entry timing has not yet shifted to later dates.

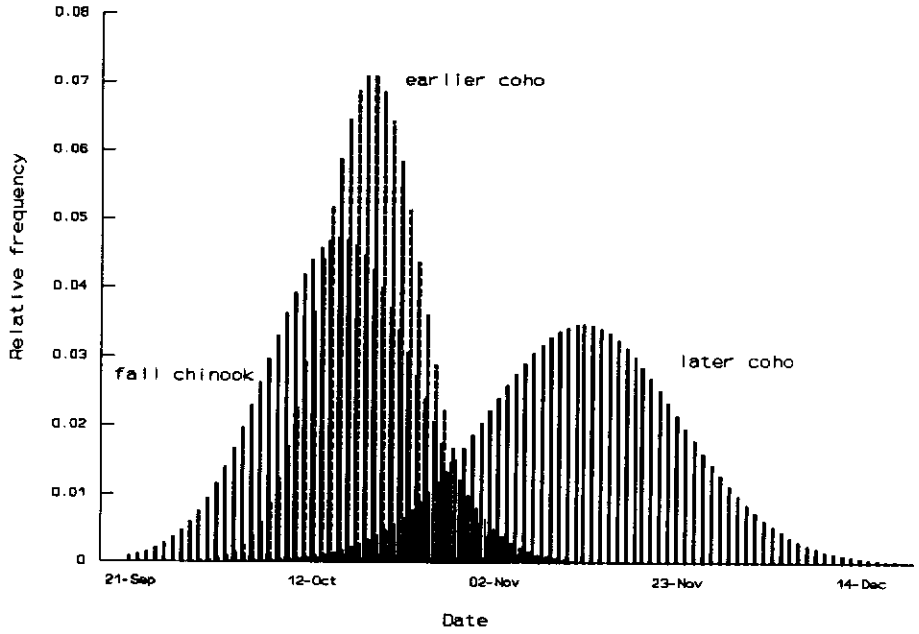

Figure 2. Makah NFH fall chinook and coho adult return timing, 1988-1991, normalized curves.

Age

Adult ages determined from scale samples taken at spawning show that about 25% of the fish returning to the hatchery are two-year-olds, about 20% are three-year-olds, about 30% are four-year-olds, and about 20% are five-year-olds (Table 6). This differs from the ages of fish caught in the fisheries, where age composition is 31% three-year-old, 51% four-year-old, and 11% five-year-old (Table 7). Since two-year-old fish are probably not present in the fishery due to minimum size limits, a more restrictive comparison of hatchery ages shows a slight tendency for more five-year-olds to the hatchery. Excluding two-year olds, age composition for fish returning to the hatchery is 28% three-year-old, 43% four-year-old, and 29% five-year-old. Mean age for males returning to the hatchery rack from release broodyears 1983 to 1986 ranges from 2.5 to 3.3 years (Table 8). Mean age for females ranges from 4.3 to 4.6 years.

Spawning

For broodyears 1986-1991, spawning dates ranged from September 26 to November 26 (Table 5). The mean spawning date, weighted by the number of fish spawned per day, was October 17.

Effective Population Size

Spawning of fall chinook at Makah is usually done by pairing individual fish. Considering the number of adults spawned at the hatchery since 1984 (Table 5), the calculated effective population size (Simon et al. 1986) is 68. This is below suggested ranges for minimum population sizes required to limit the effects of inbreeding depression (Kapuscinski and Jacobson 1987), primarily due to the limited number of adults used in 1984. Since the hatchery weir is not 100% effective at blocking the upper Sooes River, and since adult chinook spawn in the river below the hatchery, the actual population size for the system is higher than that calculated from hatchery spawners. As the chinook run builds, the calculated effective population size will increase. Tave (1986) recommends at least 424 parents for populations used in fishery management programs. The current calculated rate of inbreeding for the Makah population at an effective population size of 68 is 0.7% per generation.

Survival Trends

Tagged hatchery releases

Data from the coastwide tagging database show that Makah fall chinook are caught mainly in fisheries off Vancouver Island (Table 7). Some catch also occurs in Alaska, and a minor fraction in Washington waters. Troll fisheries are the primary harvesters of Makah fall chinook, accounting for 75% of all fishery captures. Net and seine fisheries harvest 16% of the catch and sport fisheries take 8%. Thirty-two percent of the entire catch was in Alaskan waters, 64% in Canada, and 4% in Washington. Once directed fisheries in the Sooes River take place, the proportion of the catch to Washington net fisheries should increase. Inferences about timing and location of catches in fisheries should be made cautiously. Season closures and regulation changes influence capture location and timing. The data in Table 7 are not weighted by survival rate and represent all tagged groups. Capture from year-classes with high survival will over-represent capture site and timing.

Total survival to fisheries and the hatchery rack of tag groups has ranged from 0.05% to 0.22% (Table 9). The highest survival rate from coded-wire tagging data is seen for broodyear 1987, which is still incomplete. Average total survival for coded-wire tagged broodyears 1985 to 1987 is 0.12%.

Untagged hatchery releases, before broodyear 1985

The average ratio of catch to escapement determined from tagging data for the broodyears 1985 and 1986 is 0.724. Dividing the observed adult return to the hatchery by the mean catch:escapement ratio provides estimates of total survival for the untagged broodyears 1981 to 1984 (Table 6). The mean estimated total survival rate for broodyears 1981 to 1987 is 0.84% (range 0.05% - 3.77%, Figure 3). The survival peak for broodyear 1984 reflects an anomaly seen for many other northwest chinook stocks that entered the ocean in 1985, and is probably due to favorable oceanic conditions.

Mitigation releases

Mean total tag recovery for tag groups of fall chinook released in the upper Sooes watershed as advanced fry is 0.05% (Table 9). The catch to escapement ratios for these mitigation releases show that more fish are caught than return to the hatchery rack. This is the converse of the catch to escapement ratio observed for hatchery releases. This could be an artifact of

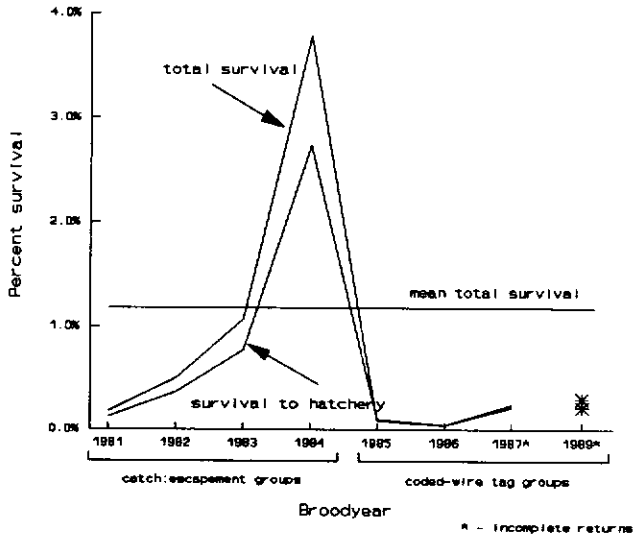

Figure 3. Total survival and survival to hatchery return for Makah NFH fall chinook.

tagging injury. Mitigation fish are tagged at a smaller size than production fish and tag-induced damage to olfactory nerves may interfere with homing (Morrison and Zajac 1987).

Discussion

Recent production at Makah has averaged about 4,600 smolts released per female spawned. At this production rate, an adult return rate of 0.043% is necessary to maintain a fixed run size (maintenance level). Return to the hatchery has averaged 0.80% (Table 6), which indicates that the run is building. All broodyears released from the hatchery have returned at a rate greater than the maintenance level. The most successful group was the 1984 brood, which returned to the hatchery at a rate of 2.73%. Releases of all groups of fall chinook in this report average 1.10% total survival to date. Based on average age at return and sex ratio data, it appears that the production goal of four million fish released from the hatchery will be met with the 1996 brood (Table 10). In the following years, surplus adults should be available to provide fish for a directed chinook harvest in the Sooes River. Equilibrium harvest would be reached in 2001. Until the hatchery production goal is met, directed chinook fisheries should continue to be restricted. Higher long-term fishery yields will result more quickly from earlier achievement of full hatchery production.

The Makah fall chinook program is comparable to other fall chinook programs in coastal Washington and the Strait of Juan de Fuca. Compared to the Makah NFH rate of 1.10%, mean total tag recovery rates (one value per broodyear, only broodyears through 1986) for other similar release programs in Washington ranged from 0.25% to 1.62% (Table 11). The combined mean recovery for these programs is 0.75%.

Wild Stock Interactions

Hatchery fall chinook probably commingle with naturally produced chinook and coho during their outmigration in the Sooes River. Then there may be competition for food resources in localized freshwater and estuarine areas. It is generally thought that forage is not a limiting factor in the marine environment (Hartt 1980). Fall chinook juveniles may be prey for steelhead and coho while migrating to the open ocean. Salmonids are not a typical component of coho and chinook marine diets (Fresh et al. 1981). In the open ocean, Makah chinook commingle with other stocks, both hatchery and wild, throughout their range. As adults, Makah fall chinook begin to enter fresh water in the early fall immediately before coho entry begins. Both species are managed as hatchery runs with additional system production provided

by passing adults or planting hatchery-produced fry above the hatchery. No straying of Makah fish to other fall chinook systems has been observed, thus no known genetic interaction at spawning is present outside of the Sooes River.

Recommendations

The following short-term recommendations are given for the Makah NFH fall chinook program:

Culture techniques

- Continue to release fish in two groups, holding one as long as possible into June, subject to water flow and temperature limitations.

Evaluation

- Continue coded-wire tagging of fall chinook to evaluate run building progress and release strategy.

Genetics

- Continue to spawn all returning adults individually to maximize genetic input.
- Continue using jacks in spawning, targeting the number used to 2% of the total population.

Management

- Continue to restrict harvest of chinook until hatchery production goals are attained.

Facility Management

- The increasing number of adult returns will require completion of automated broodstock handling facilities, requiring capital expenditures.

Longer-term recommendations include:

- Pass adults upstream in lieu of mitigation fry planting once full hatchery production is met.
- Re-assess hatchery production capacity once current production goal is met.
- Consider including releases into the nearby Waatch River and Educket Creek to increase the number of fishery sites and harvest.

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Table 1. Fall chinook returns to the Sooes River.

Return year	Fishery			escapement	to hatchery
	Sooes	Waatch	Sooes + Waatch		
1937			10		-
1938			22		-
1939			1		-
1940			31		-
1942			5		-
1943			35		-
1944			4		-
1945			27		-
1946			35		-
1947			7		-
1948			698		-
1949			45		-
1950			1851		-
1951			544		-
1952			66		-
1953			111		-
1954			127		-
1955			63		-
1956			15		-
1957			66		-
1958			53		-
1959			70		-
1960[1]			159		-
1961[1]			70		-
1962[1]			100		-
1963[1]			140		-
1964[1]			137		-
1965			102		-
1966			39		-
1967			24		-
1968			39		-
1969			46		-
1970			78		-
1971			57		-
1972			81		-
1973[2]			21		-
1974[2]	123	4	127		-
1975[2]	17	9	26		-
1976	71	13	84		-
1977	25	3	28		-
1978	4	1	5	258	-
1979[3]	12	2	14	185	-
1980[34]	-	-	0	130	-
1981[34]	-	-	0	410	-
1982[4]	-	-	0	300	-
1983	-	-	0		-
1984[5]	-	-	0		37
1985[5]	-	-	0		399
1986[5]	1	7	8		611
1987[5]	3	1	4		436
1988[5]	54	1	55		567
1989[5]	1	1	2		569
1990[5]	0	0	0		290
1991[5]	-	-	0		1551
1992[5]	-	-	0		1532

[1] - includes returns from Deschutes River and Soos Creek (Duwamish River) stock
[2] - includes returns from Minter Creek stock
[3] - includes returns from Quinault River stock
[4] - includes returns from Green River x Quinault River cross
[5] - includes returns from Makah NFH releases

Table 2. Makah NFH fall chinook released at hatchery.

Release date	Brood year	Tagcode	Fish size (g)	Fish released		
				Tagged	Adipose only	Unmarked
5/17/82	81	-	3.78	0	0	68,948
5/13/83	82	-	5.53	0	0	143,219
5/31/84	83	-	5.72	0	0	42,364
5/30/85	84	-	5.53	0	0	43,455
5/27/86	85	051744	5.70	35,827	2,246	3,655
5/27/86	85	051745	5.70	36,173	2,268	3,691
5/27/86	85	051746	5.70	35,914	2,252	3,665
5/27/86	85	051747	5.70	30,076	1,886	3,069
4/28/87-5/11/87	86	051907R4	5.50	127,387	10,180	562,947
5/16/88	87	051950R3	6.06	203,819	2,267	90,302
5/14/90-5/17/90	89	051955R3	6.78	93,972	8,160	964,570
5/26/91	90	052354	6.14	40,694	8,590	43,724
5/26/91	90	052355	6.14	47,258	5,462	46,772
6/10/91	90	052356	7.57	44,866	5,466	44,502
6/10/91	90	052353	7.57	40,859	10,517	45,426
5/26/92	91	052824	6.57	63,277	6,867	91,906
5/26/92	91	052825	8.56	67,582	2,670	94,565
6/02/92	91	052823	7.82	57,822	7,766	94,974
6/02/92	91	052822	7.56	59,703	11,085	89,943

Table 3. Makah NFH fall chinook released upstream of NFH as mitigation.

Release date	Brood year	Tagcode	Fish size (g)	Fish released		
				Tagged	Adipose only	Unmarked
4/17/86	85	B50410	1.40	5,604	57	0
4/17/86	85	B50411	1.30	5,786	58	0
4/17/86	85	B50412	1.30	3,109	31	0
4/18/87	86	B50512	1.60	30,327	5,478	0
4/18/87	86	B50513	1.60	29,923	6,303	0
4/18/87	86	B50514	1.60	31,866	1,293	0
4/22/88	87	B50301 & B50302	1.77	68,244	5,216	2,994
4/13/90	89	-	1.65	0	0	120,000[1]
3/21/91	90	-	1.11	0	0	50,000
3/27/92	91	-	1.35	0	0	119,227

[1] Sooes stock, reared at Educket Creek facility by Makah Tribe

Table 4. Fall chinook and coho adult entry into Makah NFH.

Return year	Mean hatchery entry date	
	Fall chinook	Coho
1986	October 14	-
1987	October 29	-
1988	October 8	November 4
1989	October 16	October 22
1990	October 8	October 17[1]
1991	October 18	November 1[1]
mean 1988-1991	October 15	October 29

[1] - returns from late-selected parents

Table 5. Makah NFH fall chinook, numbers spawned and date spawned.

Broodyear	Number spawned			Spawning date	
	Males	Females	Jacks	Weighted mean	Range
1984	4	10	1	-	-
1985	68	38	12	-	-
1986	140	156	17	Oct. 14	Sept. 26 - Nov. 7
1987	195	88	0	Oct. 25	Oct. 19 - Nov. 12
1988	158	264	0	Oct. 14	Sept. 21 - Nov. 7
1989	150	254	2	Oct. 17	Oct. 12 - Oct. 30
1990	90	92	0	Oct. 10	Oct. 3 - Oct. 25
1991	155	179	6	Oct. 20	Oct. 10 - Nov. 26
			mean	Oct. 16	

Table 6. Makah NFH fall chinook, returns to hatchery - by broodyear.

Broodyear	Age at return						Total for year-class	Percent return to hatchery	Percent total survival
	1	2	3	4	5	6			
1981	-	-	-	60	27	1	87	0.13%	0.18%[2]
1982	-	-	168	293	57	0	518	0.36%	0.50%[2]
1983	-	158	56	48	66	0	328	0.78%	1.08%[2]
1984	0	236	301	398	253	1	1188	2.73%	3.77%[2]
1985	0	29	29	68	38	3	167	0.10%	0.08%[3]
1986	0	74	100	122	70	2	369	0.05%	0.05%[3*]
1987	0	148	103	265	283	-	799	0.21%	0.28%[3*]
1988[1]	0	1	6	96	-	-	102	-	-
1989	25	1207	1124	-	-	-	2357	0.22%	0.22%[3*]
mean, 1982-1986		26%	22%	31%	21%			0.80%	1.10%

[1] none released from hatchery due to VHS exposure

[2] estimated from catch:escapement ratio

[3] from coded-wire tag recoveries

[*] incomplete broodyear, from recoveries to date

Table 7. Catch of Makah NFH fall chinook in fisheries for tag groups released at hatchery, broodyears 1981-1986.
values are not weighted by survival rate and represent all tagged groups

		Caught at age 2		Caught at age 3		Caught at age 4		Caught at age 5		Caught at age 6	
	Fishery	Peak month	Percent of catch	Peak month	Percent of catch	Peak month	Percent of catch	Peak month	Percent of catch	Peak month	Percent of catch
Alaska	Ocean troll	-	-	July	14%	July	41%	July	26%	-	-
	Mixed net and seine	July, Aug	18%	August	8%	-	-	-	-	-	-
	Sport	-	-	-	-	May	1%	-	-	-	-
Canada	Ocean troll	-	-	July	53%	July, Aug	43%	August	52%	August	100%
	Mixed net and seine	August	82%	July, Sept	10%	July, Aug	11%	August	9%	-	-
	Sport	-	-	August	5%	June	3%	August	13%	-	-
Washington	Treaty troll	-	-	May, Nov	3%	-	-	-	-	-	-
	Sport	-	-	August	7%	August	2%	-	-	-	-
		N = 11 fish		N = 82 fish		N = 134 fish		N = 30 fish		N = 4 fish	

Table 8. Makah NFH fall chinook mean age and length of adults returning to hatchery.

Release broodyear	Males		Females	
	Mean age, years	Mean fork length, mm	Mean age, years	Mean fork length, mm
1983	2.52	538	4.57	913
1984	3.11	708	4.44	907
1985	3.29	702	4.49	915
1986	3.12	706	4.34	905

Table 9. Makah NFH fall chinook tag recovery - data to 9/28/92.

Tagcode	Brood year	Tags recovered	Expanded recovery	Total recovery	Catch to escapement ratio
released from hatchery					
051744	85	15	21	0.06%	0.91
051745	85	27	45	0.12%	1.37
051746	85	19	24	0.07%	0.41
051747	85	15	25	0.08%	1.18
051907R4	86	53	60	0.05%*	0.48
051950R3	87	326	430	0.22%*	0.79
051955	89	85	100	0.05%*	
mitigation releases, upstream					
B50410	85	2	7	0.12%	7.00
B50411	85	3	8	0.14%	7.00
B50412	85	1	1	0.03%	0.00
B50512	86	2	7	0.02%*	-
B50513	86	0	0	0.00%*	-
B50514	86	0	0	0.00%*	-
B50301+B50302	87	13	25	0.04%*	1.78

* - recoveries to date

Table 10. Makah NFH fall chinook run projection.

$$return_{year} = \sum_{age=3}^{5} (return\ rate_{age} \times release_{year-age})$$

$$release_{year} = fecundity \times \sum_{age=3}^{5} (release_{year-age} \times return\ rate_{age} \times female\ rate_{age})$$

4,000,000 release target
4,600 released from hatchery per female spawned *(fecundity)*
1,020 adult females required, includes 150 for mitigation
2,339 adults required, includes 300 for mitigation

return to hatchery at age 3 = 0.064% *(return rate$_3$)*, percent female = 9% *(female rate$_3$)*
return to hatchery at age 4 = 0.088% *(return rate$_4$)*, percent female = 52% *(female rate$_4$)*
return to hatchery at age 5 = 0.055% *(return rate$_5$)*, percent female = 87% *(female rate$_5$)*

Brood year	Fish released	Number returning at age			Return year	Return to Sooes River		
		3	4	5		Females	Adults	Surplus
1982	143,219[1]	168[1]	293[1]	57[1]	1982			
1983	42,364[1]	56[1]	48[1]	66[1]	1983			
1984	43,455[1]	301[1]	398[1]	253[1]	1984		12[1]	
1985	175,367[1]	29[1]	68[1]	38[1]	1985		201[1]	
1986	805,704[1]	100[1]	122[1]	70[1]	1986		297[1]	
1987	369,848[1]	103[1]	265[1]	283[1]	1987		370[1]	
1989	1,066,7012[1]	1124[1]	943	583	1989		421[1]	0
1990	434,136[1]	280	384	237	1990		264[1]	0
1991	767,387[1]	494	678	420	1991		341[1]	0
1992	1,200,000	773	1,061	656	1992	287[1]	1,503[1]	0
1993	2,371,319	1,527	2,096	1,297	1993	516	1,223	0
1994	3,457,701	2,227	3,057	1,891	1994	752	1,461	0
1995	2,892,965	1,863	2,557	1,582	1995	629	1,689	0
1996	4,000,000	2,576	3,536	2,188	1996	1,054	3,008	669
1997	4,000,000	2,576	3,536	2,188	1997	1,862	4,979	2,640
1998	4,000,000	2,576	3,536	2,188	1998	2,886	6,217	3,878
1999	4,000,000	2,576	3,536	2,188	1999	3,207	7,025	4,686
2000	4,000,000	2,576	3,536	2,188	2000	3,447	7,694	5,355
2001	4,000,000	2,576	3,536	2,188	2001	3,974	8,300	5,961
2002	4,000,000	2,576	3,536	2,188	2002	3,974	8,300	5,961
2003	4,000,000	2,576	3,536	2,188	2003	3,974	8,300	5,961

[1] - actual

Table 11. Other Washington coast and Strait of Juan de Fuca fall chinook programs tag recovery, data to 9/28/92.

Tag code	Brood year	Hatchery	Date released	Size at release (g)	Tags recovered	Expanded recovery	Total recovery	Mean recovery
633038	83	Elwha River spawning channel	6/15/84	7.6	76	177	0.70%	
633039	83	Elwha River spawning channel	6/15/84	7.6	89	245	0.98%	
633042	83	Elwha River spawning channel	8/4/84	11.3	3	9	0.03%	
633043	83	Elwha River spawning channel	8/4/84	11.3	1	2	0.01%	
633419	84	Elwha River spawning channel	6/21/85	7.3	116	250	0.94%	
633420	84	Elwha River spawning channel	6/21/85	7.3	91	231	0.88%	0.39%
633435	84	Elwha River spawning channel	8/04/85	10.1	14	38	0.15%	
633436	84	Elwha River spawning channel	8/04/85	10.1	12	30	0.12%	
633543	85	Elwha River spawning channel	6/10/86	7.3	64	118	0.45%	
633544	85	Elwha River spawning channel	6/10/86	7.3	49	123	0.47%	
633547	85	Elwha River spawning channel	7/13/86	9.1	1	1	0.00%	
633548	85	Elwha River spawning channel	7/13/86	9.1	1	1	0.00%	
632837	83	Naselle SFH	6/01/84	6.1	291	541	0.72%	
632847	83	Naselle SFH	6/01/84	6.1	289	563	0.75%	
633331	84	Naselle SFH	6/19-26/85	4.7	231	430	0.83%	0.61%
633332	84	Naselle SFH	6/19-26/85	4.7	260	449	0.87%	
633333	84	Naselle SFH	6/19-26/85	4.7	244	510	0.98%	
634107	85	Naselle SFH	6/9-13/86	5.5	206	407	0.20%	
633229	84	Humptulips SFH	6/27/85	3.0	96	320	0.54%	
633230	84	Humptulips SFH	6/27/85	3.0	101	257	0.44%	
633231	84	Humptulips SFH	6/27/85	3.0	97	248	0.42%	0.47%
632842	85	Humptulips SFH	7/07/86	3.5	370	947	0.44%	
634414	86	Humptulips SFH	7/07/87	4.9	337	1022	0.51%	
633404	84	Nemah SFH	6/10/85	5.3	186	342	0.68%	
633405	84	Nemah SFH	6/10-17/85	5.3	184	382	0.77%	
633406	84	Nemah SFH	6/17/85	5.2	183	359	0.72%	
633823	85	Nemah SFH	6/10-17/86	5.0	76	155	0.33%	0.51%
633824	85	Nemah SFH	6/10-17/86	5.0	72	164	0.32%	
633825	85	Nemah SFH	6/10-17/86	5.0	75	147	0.28%	
633826	85	Nemah SFH	6/10-17/86	5.0	79	142	0.27%	
051463	83	Quinault NFH	8/20/84	15.1	500	1266	2.73%	
211654	84	Quinault NFH	8/07/85	11.8	397	1113	2.14%	1.62%
211904	85	Quinault NFH	7/31/86	11.6	1243	2786	1.38%	
212102	86	Quinault NFH	7/14/87	11.1	195	445	0.22%	
H10405	83	Soleduck SFH	8/13/84	8.3	3	5	0.03%	
633317	84	Soleduck SFH	8/08/85	8.9	160	324	0.43%	
633318	84	Soleduck SFH	8/08/85	8.9	172	414	0.55%	0.25%
633319	84	Soleduck SFH	8/08/85	8.9	159	340	0.45%	
633120	83	Willapa SFH	6/12/84	6.9	364	664	0.88%	
633121	83	Willapa SFH	6/13/84	5.3	563	1060	1.38%	
633239	84	Willapa SFH	5/29-30/85	5.9	285	613	1.19%	
633240	84	Willapa SFH	6/12/85	5.2	296	573	1.08%	
633241	84	Willapa SFH	7/02/85	5.7	377	902	1.80%	0.83%
633816	85	Willapa SFH	6/03/86	5.5	127	261	0.50%	
633817	85	Willapa SFH	6/03/86	5.5	115	245	0.47%	
633818	85	Willapa SFH	6/03/86	5.5	132	318	0.61%	
634125	86	Willapa SFH	5/8-20/87	4.9	241	624	0.30%	